In-Stride Battlespace Characterization

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Abstract - *Decades of sustained military oceanographic survey work and data processing have been conducted by the Naval Oceanographic Office in an effort to accurately characterize the Arabian Gulf battlespace. Knowledge of the battlespace provides assured access to forward operating areas essential for the Navy's power projection mission. Gaps in knowledge of the battlespace identified while preparing for Operation Iraqi Freedom provided an opportunity to adaptively employ survey assets and sensors for rapid environmental assessment of prioritized areas in the North Arabian Gulf. Those efforts demonstrated the capability and potential to rapidly conduct oceanographic surveys and process data into knowledge "in-stride" to support more agile and mobile Naval forces. Emerging on-board and off-board Anti-submarine Warfare and Mine Warfare systems will yield technology that may be harnessed to organically collect environmental data. Data collection is only one component of in-stride battlespace characterization which is comprised of both rapid data collection and on-scene data processing. Three challenges must be overcome to achieve full potential for a naval in-stride battlespace characterization capability: identify and correct gaps in data collection capabilities, develop a concept of operations for in-stride battlespace characterization, and accelerate R&D of data integration, assimilation, and automatic processing algorithms. As speed and mobility become hallmarks of our Navy, we will need to develop a robust capability to extend foundational oceanographic databases shoreward, through the shallow waters of the littoral, across the mission spectrum from peacetime to hostilities. The opportunity to develop a littoral warfare force multiplying in-stride battlespace characterization capability is upon us now.*

I. INTRODUCTION

Assured Access is the key that unlocks the door to allow the U.S. Navy to dominate any battlespace when and where required. Our Chief of Naval Operations sums up the importance of assured access in his 15 second sound-bite commercial for the U.S. Navy: "Credible combat, far corners of the earth, sovereignty of the United States, options for the President, anywhere, anytime, without a permission slip." For decades, the Naval Oceanographic Office (NAVOCEANO) has been collecting data from the world's oceans and processing that data into relevant oceanographic knowledge in support of assured access for the Navy. Over the years of strategic, methodical military survey operations, terabytes of data were collected, analyzed, and processed to fulfill combatant commander oceanographic requirements. These requirements span multiple warfare areas on the strategic, operational, and tactical scales of warfare. Anti-Submarine Warfare (ASW), Expeditionary Warfare (EXW), Mine Warfare (MIW), and Special Operations Forces (SOF) are significantly impacted by knowledge of the undersea operating environment. Knowing the environment better than our adversary is a critical element of assured access

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and yields powerful tactical advantage. The sum total knowledge of the operating environment can be classified simply as "battlespace characterization." This paper describes the need and challenges of developing an in-stride battlespace characterization capability and expectations of using Through-The-Sensor (TTS) technology to support it.

II. BACKGROUND

According to a Defense News article on 26 May, 2003, the Defense Advanced Research Agency (DARPA) is leading an 18 month Littoral Naval Force Architecture Study [1] to determine technologies and capabilities the U.S. Navy will need in the next decade to ensure unconstrained access to the littoral. The Defense News article states that "Officials are especially concerned about the proliferation among coastal nations of weapons that could deny U.S. Navy access to littoral waters, such as mines, diesel submarines, and small swarming boats." The LCS Concept of Operations (CONOPS) of Feb 2003 [2] echoes those concerns in stating "In addition to the difficulties of navigating in foreign waters (especially at night, in shallow areas, and in poor weather), the littorals shelter unique threats, such as submarines in shallow water, minefields, and small craft that may hide among civilian shipping in preparation for a coordinated multi-unit attack. These and other threats employed by an asymmetrically thinking enemy that uses readily available off the shelf technology to exploit the seams and vulnerabilities in our current force mix are the exigencies of Sea Shields battlespace access component." Oceanographic information superiority provided by accurate battlespace characterization is a deciding factor of operational mission success in the high-threat littorals.

Operation Iraqi Freedom (OIF) revealed an inflection point in the evolution of battlespace characterization and perhaps may be considered revolutionary for the future of assured access. Characterization of the Central Command (CENTCOM) battlespace was not a trivial matter. Over the past two decades, the Navy has invested nearly 30 ship-years of survey efforts throughout the CENTCOM area of responsibility to fulfill numerous high priority oceanographic requirements. The national return-on-investment of that sustained level of oceanographic survey effort was assured access for OIF of a quality unprecedented in the history of naval warfare. The tangible output of decades of sustained survey efforts is surface and submerged navigation charts, MIW, EXW and ASW tactical decision aid (TDA) databases, real time environmental characterization and knowledge of the physical oceanographic characteristics that permitted assured access during conflict. Data collected through survey efforts is also essential for development of sophisticated physical oceanographic computer models that predict future battlespace conditions. The Oceanographer of the Navy asserts that information superiority must be supported by populating the “4-D Cube” (X,Y,Z,T) with spatial environmental knowledge of the battlespace complimented by the ability to forecast environmental conditions in the future (the time element of the 4-D cube). NAVOCEANO plays a major role in populating the “4-D Cube” which is foundational to the development of a Common Operational Picture (COP).

III. THE NEED FOR IN-STRIDE BATTLESPACE CHARACTERIZATION

Although methodical military oceanographic survey activities will continue to be necessary to build foundational products such as navigation charts and tactical databases integral to assured access, battlespace characterization must evolve to meet the

needs of a faster, more mobile and agile Navy. Battlespace characterization must be extended from the foundational databases shoreward, through the shallow waters of the littoral, when and where needed without the need for a "permission slip." Essential components of battlespace characterization must be conducted "in-stride" by organic assets in contested areas. Without the ability to characterize bathymetry (the topography of the ocean bottom), beach slope, currents, temperature and salinity, acoustic transmission properties, optics, tides, waves, sediment properties, and other fundamental physical characteristics of the battlespace, USW, MIW, EXW, SOF, and other warfare area capabilities will be unable to achieve full power projection potential and assured access will be limited. "In-stride battlespace characterization" (hereafter called ISBC) will become particularly important in the era of the littoral combat ship (LCS) and Expeditionary Strike Groups (ESG). These operations will need timely environmental information in shallow territorial seas where existing data holdings may be sparse or dated. Assured access can only be guaranteed if we seamlessly integrate foundational oceanographic knowledge (developed by permissive, methodical military survey activities) with data collected rapidly in dangerous and contested areas as we progress across the mission spectrum from peacetime, to contingency tasking, to pre-conflict, to precursor operations, to hostilities.

IV. PROTOTYPE ISBC

Although strategists predominately focus on asymmetric threats, the U.S. Navy frequently employs asymmetric means to our own advantage. For example, our oceanographic capabilities are convincingly asymmetric as compared with our closest allies and competitors. NAVOCEANO exercises technical control of the world's largest fleet of military survey ships (seven T-AGS survey ships) and other impressive survey assets. Gross tonnage not withstanding, the true measure of asymmetric oceanographic capabilities lies in the ability to convert survey data into knowledge and to apply that knowledge within the warfighters decision loop. Even with formidable oceanographic assets committed to surveying the Arabian Gulf, gaps in knowledge of the battlespace environment were identified by NAVCENT during the build-up to OIF. To close those gaps quickly, adaptive employment of NAVOCEANO assets were brought to bear. Keeping with the famed accomplishments of the ship’s namesake, Matthew Henson (co-discoverer of the North Pole), USNS Henson (T-AGS 63) was augmented with Marines and surged into the Arabian Gulf to survey a navigation route to accommodate the deep draft WATSON class roll-on, roll-off pre-positioning ships. USNS Henson also conducted a physical oceanographic survey to verify and fine-tune Arabian Gulf circulation models used for prediction of currents affecting oil spills, SOF operations, and mine drift predictions. NAVOCEANO employed various other assets, including its Fleet Survey Team (A rapid response military team for emergent hydrographic and oceanographic survey work), to deploy floating and moored oceanographic sensors for "Rapid Environmental Assessment" (REA) to ensure a continuous, near-real-time data stream of “observed” oceanographic conditions throughout the duration of OIF operations. The Fleet Survey Team surged into Kuwait in the weeks prior to OIF to survey shallow waters and produce large-scale navigation field charts in support of coalition logistics. These operational and tactical support efforts represent transformation of legacy peacetime survey capabilities into a wartime capability and serve as a prototype for ISBC.

Prototype ISBC methods were successfully employed before and during OIF due to years of

battlespace characterization experiments conducted for the Ship Anti-Submarine Warfare Readiness Effectiveness Measuring (SHAREM) exercise program. This program has provided a laboratory for development of an ISBC model. During SHAREMs, NAVOCEANO employs T-AGS survey ships plus organic air and surface assets to deploy oceanographic sensors for rapidly assessing the environment. Acoustic transmission loss measurements are collected in the SHAREM exercise areas from calibrated sound sources as well as from hull mounted sonars. Conductivity, Temperature, Depth (CTD) soundings and current meters measure physical oceanographic parameters. Ambient noise is measured by specially designed Environmental Acoustic Recording System (EARS) buoys. “Chirper,” “Sparker,” and “Airgun” equipment assess sediment characteristics. Essentially, the environmentally-dependent parameters of the sonar equation are determined by converting rapidly collected data into oceanographic knowledge relevant to the success of ASW.

V. THROUGH-THE-SENSOR TECHNOLOGY

Navy submarine, littoral, and mine-warfare acquisition programs are beginning to yield technology that will enable organic MIW and ASW. These new sensors and systems will directly or derivatively measure environmental characteristics in-stride during normal fleet operations. The systems are employed both on-board and off-board gray hull ships, submarines, and aircraft. For example the Battlespace Profiler Autonomous Underwater vehicle (BPAUV) is envisioned to be a dedicated oceanographic measurement system. The Mission Reconfigurable Unmanned Underwater Vehicle (MRUUV) may have a battlespace profiler payload option. The Airborne Laser Mine Detection system (ALMDS) is an example of a sensor designed to detect mines that may be used secondarily to measure near-shore bathymetry. Another emerging off-board system capable of collecting environmental data in-stride is the Long-term Mine Reconnaissance System (LMRS) [3]. These and many other emerging high-tech systems may all be grouped loosely into a category called "Through-the-sensor" (TTS) environmental data collectors.

VI. ISBC CHALLENGES

Although emerging TTS systems have great potential for ISBC, three critical challenges must be overcome for ISBC to come into fruition and become a powerful force multiplier in future littoral combat:

1) Identify critical gaps in in-stride data-collection capabilities and close those gaps with modified mission payloads or augmentation of TTS capabilities.
2) Develop CONOPS for ISBC and dedicate a proportion of operational assets to accomplish the battlespace characterization mission.
3) Accelerate and expand R&D of data integration and assimilation capabilities, automated recognition and processing algorithms, and build hooks into appropriate Tactical Decision Aids (TDA’s).

A. Challenge #1: Identify In-Stride Data Collection Capability Gaps:

Emerging littoral warfare sensors have a wide range of oceanographic sensors depending upon particular missions. Spatial coverage will be limited with nearly all TTS sensors but that is an assumed limitation of ISBC and justifies the continued requirement for strategic, foundation-building military

oceanographic surveys. Depth sounding sonars, acoustic and optical imaging sensors, Acoustic Doppler Current Profilers (ADCP), and Conductivity, Temperature and Depth (CTD) sensors are mainstays of Unmanned Underwater Vehicles (UUVs) under development. Capabilities to collect bathymetry data and acoustic imagery of the seafloor are the most common elements of emerging MIW systems. The most obvious capability gaps in emerging data collection systems include the inability to measure acoustic transmission loss and assess sub-bottom sediment characteristics. Knowledge of the characteristics of how sound propagates through the water column and sub-bottom is imperative to gaining the tactical advantage in ASW and MIW. Today, NAVOCEANO employs seismic survey methods including high-pressure air-guns and high-voltage sparkers to collect data for determination of seafloor characteristics. Transmission loss measurement currently involves the use of a calibrated explosive sound source together with a large specialized hydrophone buoy affectionately named “Buoyzilla” due to its large size and weight. Transmission loss and seafloor characterization presently requires heavy, roll-on, roll-off equipment operated from dedicated oceanographic survey ships (T-AGS). There are obvious S&T challenges to overcome if transmission loss or sediment classification is expected to be accomplished in-stride.

B. Challenge #2: ISBC CONOPS:

Simply because an emerging MIW or ASW system will have inherent capability to measure and record oceanographic parameters does not mean that it will significantly contribute to effective battlespace characterization. Even on a small-scale, characterizing the battlespace requires time-consuming, coordinated sampling efforts. As an illustration, consider the potential employment of the Airborne Laser Mine Detection System (ALMDS) being designed to fly aboard the MH-60 MIW helicopter. High demand and limited endurance of the MH-60 may prevent deliberate use of the ALMDS to fly a grid pattern over a beach of interest to conduct a beach slope survey. The principal mission of the ALMDS will be for mine detection and that will understandably drive its employment. Use of a dedicated ISBC system such as the BPAUV and MRUUV (BP payload) will always be a more effective in-stride Battlespace Characterization asset. The challenge at hand is to develop an effective CONOPS to coordinate and specify the most efficient and effective employment of emerging TTS capabilities in support of ASW, MIW, EXW, and SOF missions.

C. Challenge #3: Data Integration and Assimilation R&D:

Raw or partially processed oceanographic data is practically useless to the warfighter. NAVOCEANO’s mission is to collect oceanographic data, process it into relevant oceanographic knowledge, and apply that knowledge across the full spectrum of warfare. The T-AGS survey ships have a customized information system that integrates the entire suite of shipboard mission system sensors using a common geospatial reference system. Once all data are integrated using this Integrated Survey System, onboard knowledge workers quality-assure the data and perform manual data editing and processing in preparation for comprehensive shore processing. Although some automated processing is accomplished, much of the data processing is still manually intensive. For ISBC to reach full potential, more R&D is required to develop TTS data

assimilation, integration, QA/QC, automated feature recognition, and data-base development for hooks into standard TDA's. As ISBC evolves and data handling systems and algorithms mature, the need for knowledge workers embedded in the process should decline. Although It is difficult to conceive that knowledge workers can be totally replaced by ISBC technology in the foreseeable future, good R&D can minimize the need for human knowledge workers in the ISBC process. Integrating disparate TTS sensors from multiple platforms and then processing the data into knowledge in the field is a Herculean challenge that can only be overcome by systems engineering and dedicated R&D efforts. ISBC must be comprised of both in-stride data collection and processing which implies that large climatological databases will be available to the on-scene data integrator/processor.

VII. CONCLUSION

During a conversation with VADM Keating, Commander Naval Central Command, in September 2003, he asked a poignant question concerning how NAVOCEANO transitions from a peacetime survey asset to a wartime capability. At the time, the answer was that NAVOCEANO is primarily a peacetime asset and that survey operations cease when the hostilities phase approaches. Recognizing the need for battlespace characterization across the entire mission spectrum, NAVOCEANO adapted the use of peacetime assets and stretched the Fleet Survey Teams capabilities during OIF to serve as a proof-of-concept for Rapid Environmental Assessment and In-Stride Battlespace Characterization. The opportunity to develop this fledgling ISBC concept into a powerful littoral warfare force multiplier and a guarantor of assured access is upon us today. CARPE DIEM!

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